

APPENDIX B

Soil Physical Properties

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B-1.0 INTRODUCTION

Appendix B presents the procedures and calculations employed to approximate the properties of soil in the offsite source area. This data is assembled for use in the estimation and modeling sections of this report.

B-2.0 DEVELOPMENT OF SOIL PHYSICAL PROPERTY ESTIMATES

Soil samples have been collected specifically for analysis of soil physical properties from various locations both on-site and off-site as part of past soil boring activities. Thirty-eight of these samples have been submitted for analyses to estimate the physical properties of the soil. Six soil samples were collected from soil boring locations K21, K32, TA7, TA22, TA24, and TA28 for evaluation of soil physical properties as part of on-site investigations in 2000 (Equilon 2001). Six soil samples were collected from soil boring locations R-49 through R-54 for evaluation of soil physical properties as part of the LNAPL distribution and lithologic characterization activities conducted in 2003 (LFR 2003a). Fifteen soil samples were collected from soil boring locations ASM-02, ASM-04, and AS-07 for evaluation of soil physical properties as part of the Remediation System Technical Evaluation (LFR 2003b). Eleven additional samples have been collected from soil boring locations RW-22, RW-24, RW-26, RW-27, RW-29, RW-33, RW-34, SV-16, and SV-17 during the installation of soil vapor extraction wells and soil vapor monitoring wells in November 2003 (lab reports for these samples are attached to this appendix). The samples were submitted to an analytical laboratory for analyses to determine soil physical properties. Specifically, samples have been analyzed for one or more of the following properties: bulk and grain soil density, total and air filled porosity, water content, water and NAPL saturation, intrinsic permeability, native-state permeability to air, grain-size distribution, and capillary pressure at multiple values of water saturation for air displacing water.

Data from these laboratory analyses were compiled and reviewed to determine which samples were useful in characterizing the physical properties of residual LNAPL-affected soil in the off-site area. Each sample was assigned to one of three depth intervals based on sample depth, soil type identified on borehole lithologic logs, and physical properties such as intrinsic permeability, moisture content, particle size distribution, and capillary pressure distribution. The three depth intervals are termed silty sand interval, clayey silt interval, and well-graded sand interval. The samples from each depth interval were evaluated to estimate average soil physical property values.

Analytical laboratory reports have been previously submitted in cited reports where applicable. Reports not previously submitted have been attached to this appendix. Physical property data and capillary pressure data are summarized in Tables B-1 and B-2.

B-2.1 Basic Physical Property Estimates

Evaluation of the soil property data has provided estimated average values for each of three soil types predominant in the residual LNAPL-affected soil in the off-site area. This evaluation indicates the silty sand interval has an estimated average bulk density of 1.58 grams per cubic centimeter (g/cc), and average total porosity of 39.9 percent, and an estimated geometric mean permeability of 1,500 millidarcy (equivalent saturated hydraulic conductivity of 4.0 ft/day). The clayey silt interval has an estimated average bulk density of 1.60 g/cc, an estimated average total porosity of 40.1 percent, and an estimated geometric mean permeability of 6.2 millidarcy (equivalent saturated hydraulic conductivity of 1.7×10^{-2} ft/day). The well-graded sand interval has an estimated average bulk density of 1.54 g/cc, an estimated average total porosity of 39.6 percent, and an estimated geometric mean permeability of 35,000 millidarcy (equivalent saturated hydraulic conductivity of 96 ft/day). Additional soil property estimates and statistics of the sample populations are presented in Table B-3. The standard deviation presented for the geometric mean permeability is standard deviation of the log-transformed data. As such, it should be applied to the mean estimate as the log of a multiplicative factor rather than as an additive quantity, e.g., the permeability value, k' , that is one standard deviation above the mean, would be calculated as:

$$k' = \bar{k} \times 10^{\sigma_{\log(k)}} \quad \text{B.1}$$

where \bar{k} is the geometric mean permeability value [L^2], and $\sigma_{\log(k)}$ is the standard deviation of the log-transformed data.

B-2.2 Capillary Pressure – Saturation Curve Fitting

Capillary pressure – saturation behavior is modeled using the expression proposed by van Genuchten (1980),

$$S = S_r + (S_s - S_r) \left[1 + (\alpha P_c)^n \right]^{-m} \quad \text{B.2}$$

where S_r is residual saturation [-], S_s is satiated saturation [-], P_c is capillary pressure [L], and α [L^{-1}], n [-], and m [-] are van Genuchten parameters. The parameters n and m are related by $n=1/(1-m)$. The parameters S_r , α , and n are estimated by fitting Equation B.2 to the composite capillary pressure – saturation data for each soil type. The satiated saturation, S_s , is assumed to equal one. The best fit curve and estimated parameters are evaluated by minimizing the sum of the squared differences between measured and predicted saturation values at the given capillary pressures. Figures B-1 through B-3 show the data and the best fit curves for each soil type.

The standard error on each fitting parameter is evaluated as the square root of the values on the diagonal of the covariance matrix, \mathbf{C}_{pp} ,

$$\mathbf{C}_{pp} = s_0^2 (\mathbf{J}^T \mathbf{J})^{-1} \quad \text{B.3}$$

where s_0^2 is the sum of the squared error and \mathbf{J} is the Jacobian matrix.

$$J_{ij} = \frac{\partial z_i}{\partial p_j} \quad \text{B.4}$$

is an element of the Jacobian matrix where z_i is the i^{th} predicted value (of saturation for this problem), and p_j is the j^{th} parameter. Note because n and m are not independent, Jacobian elements and standard errors for parameter m are not evaluated.

Standard errors are shown in Table B-3 for each of the fitting parameters and soil types. The fitting parameters are perturbed by one standard error to show the confidence interval of the curve fits shown on Figures B-1 through B-3.

B-3.0 REFERENCES

- Equilon. 2001. Conceptual Site Model Report, Equilon Mission Valley and San Diego Terminals, 9950 San Diego Mission Road, San Diego, California. November 2.
- LFR. 2003a. Additional LNAPL Distribution and Lithologic Characterization, Mission Valley Terminal, 9950 and 9966 San Diego Mission Road, San Diego, California. December 12.
- LFR. 2003b. Remediation System Technical Evaluation Report, Mission Valley Terminal, San Diego, California. July 8.
- van Genuchten, M.Th. 1980. A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. Soil Sci. Soc. Am. J. 44:892–898.

Table B-1
Physical Properties Data and Particle Size Summary
Mission Valley Terminal, San Diego, CA
LFR 002-10180-13

SAMPLE ID	DEPTH, ft.	GENERAL AREA	DEPTH INTERVAL	SAMPLE ORIENT. ⁽¹⁾	MOISTURE CONTENT (% wt)	DENSITY		POROSITY, %Vb ⁽²⁾		PORE FLUID SATURATIONS, % Pv ⁽³⁾		INTRINSIC PERMEABILITY ⁽⁴⁾ (millidarcy)	Description USCS/ASTM ⁽⁵⁾	Median Grain Size mm	Particle Size Distribution, wt. Percent					Silt & Clay	
						BULK (g/cc)	GRAIN (g/cc)	EFFECTIVE	AIR FILLED	WATER	HYDROCARBON				Gravel	Sand Size	Coarse	Medium	Fine		
ASM-04-08.0	8.00	Offsite	VZ SM	V	11.8	1.57	2.64	40.4	21.7	46.1	<0.01	NA	NA	NA	NA	NA	NA	NA	NA		
ASM-04-10.0	10.00	Offsite	VZ SM	V	19.4	1.58	2.69	41.2	10.4	74.6	<0.01	NA	NA	NA	NA	NA	NA	NA	NA		
ASM-04-12.5	12.50	Offsite	VZ SM	V	22.6	1.41	2.75	48.5	16.6	65.7	<0.01	NA	NA	NA	NA	NA	NA	NA	NA		
ASM-04-15.0	15.00	Offsite	VZ SM	V	16.7	1.65	2.62	36.9	9.2	75.0	<0.01	NA	NA	NA	NA	NA	NA	NA	NA		
ASM-04-18.5	18.50	Offsite	VZ SM	V	22.6	1.43	2.64	45.9	13.6	70.2	<0.01	NA	NA	NA	NA	NA	NA	NA	NA		
ASM-04-19.5	19.50	Offsite	VZ SM	V	14.3	1.62	2.64	38.4	15.1	60.5	<0.01	NA	NA	NA	NA	NA	NA	NA	NA		
RW-22-21.0-22.5	21.2	Offsite	VZ SM	V	16.1	1.55	2.63	41.0	16.0	60.9	NA	NA	NA	NA	NA	NA	NA	NA	NA		
RW-24-17.5	17.2	Offsite	VZ SM	V	17.1	1.71	2.63	35.1	5.6	84.1	NA	NA	NA	NA	NA	NA	NA	NA	NA		
RW-26-17.5	17.5	Offsite	VZ SM	V	10.2	1.53	2.63	41.8	25.9	38.0	NA	NA	NA	NA	NA	NA	NA	NA	NA		
RW-27-17.0-18.0	17.5	Offsite	VZ SM	V	8.5	1.53	2.66	42.6	29.5	30.8	NA	NA	NA	NA	NA	NA	NA	NA	NA		
RW-33-12.0	12.0	Offsite	VZ SM	V	7.0	1.35	2.64	48.9	39.4	19.4	NA	NA	NA	NA	NA	NA	NA	NA	NA		
RW-34-11.5-12.5	12.5	Offsite	VZ SM	V	18.8	1.59	2.63	39.7	9.5	76.1	NA	NA	NA	NA	NA	NA	NA	NA	NA		
SV-16-08.5	8.50	PropBound	VZ SM	NA	12.8	1.46	NA	NA	NA	NA	NA	NA	Fine sand	0.377	0.00	0.00	44.26	41.95	9.17	4.61	13.78
TA22	16.00	PropBound	VZ SM	V	14.9	1.80	2.64	32.1	5.5	86.5	<0.1	21689	Medium sand	0.439	5.53	5.20	41.85	40.16	(7)	(7)	7.26
TA24	16.00	PropBound	VZ SM	V	15.8	1.69	2.64	36.1	9.6	76.0	<0.1	1645	Fine sand	0.384	0.00	0.00	44.82	39.54	12.28	3.36	15.64
K32	12.00	S. Terminal	VZ SM	V	6.4	1.63	2.64	38.2	27.9	29.2	<0.1	612	Medium sand	0.477	0.00	0.00	57.81	25.34	12.71	4.14	16.85
R-49-14.5	14.5	S. Terminal	VZ SM	V	8.4	1.81	2.66	31.9	16.7	46.8	0.8	203	Medium sand	0.685	10.92	14.00	47.75	23.28	(7)	(7)	4.05
ASM-04-20.5	20.50	Offsite	CF MH	V	24.0	1.39	2.65	47.5	14.0	70.3	<0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	
ASM-04-21.5	21.50	Offsite	CF MH	V	21.3	1.56	2.64	41.0	7.8	80.8	<0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	
RW-29-15.5-16.5	16.0	Offsite	CF MH	V	19.5	1.59	2.63	39.5	8.1	79.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
SV-16-17.5	17.50	PropBound	CF MH	NA	13.1	1.74	NA	NA	NA	NA	NA	NA	Fine sand	0.209	0.00	0.00	21.94	44.08	20.32	13.65	33.98
R-50-14.5	14.5	S. Terminal	CF MH	V	16.2	1.56	2.64	40.8	14.9	62.3	1.2	77	Fine sand	0.313	0.00	0.00	32.26	49.04	12.65	6.05	18.71
R-51-11.0	11.0	S. Terminal	CF MH	V	18.1	1.57	2.64	40.7	11.8	69.9	1.0	22.1	Fine sand	0.193	0.00	0.00	18.36	51.89	20.95	8.79	29.75
R-52-12.0	12.0	S. Terminal	CF MH	V	17.3	1.67	2.64	36.6	7.2	79.6	0.9	2.54	Fine sand	0.192	0.00	0.00	27.55	40.43	22.72	9.29	32.01
R-53-13.5	13.5	S. Terminal	CF MH	V	19.1	1.67	2.64	36.7	4.1	86.6	2.4	1.14	Fine sand	0.138	0.00	0.00	24.50	39.31	26.17	10.01	36.18
R-54-12.5	12.5	S. Terminal	CF MH	V	20.3	1.64	2.64	37.8	4.2	88.8	<0.1	1.85	Fine sand	0.116	0.00	0.00	17.37	44.16	27.46	11.01	38.47
AS-07-25.0	25.00	Offsite	SZ SW	NA	NA	1.45	2.74	38.5	NA	NA	NA	NA	Fine sand	0.251	0.00	0.00	19.07	70.14	8.29	2.49	10.78
AS-07-28.5	28.50	Offsite	SZ SW	NA	NA	1.39	2.73	41.3	NA	NA	NA	NA	Fine sand	0.204	0.00	0.00	11.75	75.20	11.01	2.05	13.06
ASM-02-23.5	23.50	Offsite	SZ SW	NA	NA	1.59	2.74	42.0	NA	NA	NA	NA	Fine sand	0.090	0.00	0.00	6.48	47.33	35.06	11.13	46.19
ASM-02-25.5	25.50	Offsite	SZ SW	NA	NA	1.46	2.68	45.5	NA	NA	NA	NA	Fine sand	0.408	0.00	0.00	48.41	41.42	8.05	2.11	10.17
ASM-04-22.5	22.50	Offsite	SZ SW	V	10.9	1.51	2.64	42.7	26.2	38.7	<0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	
ASM-04-23.5	23.30	Offsite	SZ SW	V	13.9	1.62	2.32	30.2	7.5	74.9	<0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	
ASM-04-24.5	24.30	Offsite	SZ SW	V	24.5	1.56	2.65	41.0	2.7	93.2	<0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	
TA28	18.00	PropBound	SZ SW	V	11.4	1.70	2.63	35.3	16.4	56.0	<0.1	35135	Fine sand	0.361	0.00	0.00	41.27	38.52	15.90	4.31	20.21
SV-17-06.9	6.90	N. Terminal	NU	NA	22.0	1.57	NA	NA	NA	NA	NA	NA	Fine sand	0.043	0.00	0.00	8.58	32.47	38.94	20.01	58.95
SV-17-09.5	9.50	N. Terminal	NU	NA	20.8	1.77	NA	NA	NA	NA	NA	NA	Fine sand	0.065	0.00	0.00	6.07	41.22	35.63	17.09	52.71
TA7	12.00	N. Terminal																			

Table B-2
Capillary Pressure Data
Mission Valley Terminal, San Diego, CA
LFR 002-10180-13

SAMPLE ID	DEPTH INTERVAL	Capillary Pressure		Height Above Water Table, ft	Saturation, % Pore Volume	Moisture, % dry weight
		psi	cm water			
T28 @ 18'	SZ SW	0.000	0.00	0.000	100.0	19.3
		0.086	6.07	0.200	100.0	19.3
		0.194	13.6	0.449	100.0	19.3
		0.345	24.3	0.799	100.0	19.3
		0.539	37.9	1.25	100.0	19.3
		0.776	54.6	1.80	82.9	16.0
		1.057	74.3	2.45	76.5	14.8
		1.38	97.0	3.19	70.8	13.7
		2.16	152	4.99	61.2	11.8
		3.11	218	7.19	53.5	10.4
		4.23	297	9.78	47.6	9.2
		5.52	388	12.8	42.6	8.3
		6.99	491	16.2	39.9	7.7
		8.63	607	20.0	37.9	7.3
		19.41	1365	44.9	33.5	6.5
TA22 @ 16'	VZ SM	0.000	0.00	0.000	100.0	18.2
		0.086	6.07	0.200	100.0	18.2
		0.194	13.6	0.449	100.0	18.2
		0.345	24.3	0.799	96.8	17.6
		0.539	37.9	1.25	94.6	17.2
		0.776	54.6	1.80	92.9	16.9
		1.057	74.3	2.45	92.2	16.8
		1.38	97.0	3.19	90.7	16.5
		2.16	152	4.99	89.0	16.2
		3.11	218	7.19	87.2	15.9
		4.23	297	9.78	83.1	15.1
		5.52	388	12.8	81.2	14.8
		6.99	491	16.2	79.5	14.5
		8.63	607	20.0	77.7	14.2
		19.41	1365	44.9	73.4	13.4
TA24 @ 16'	VZ SM	0.000	0.00	0.000	100.0	20.3
		0.086	6.07	0.200	100.0	20.3
		0.194	13.6	0.449	100.0	20.3
		0.345	24.3	0.799	100.0	20.3
		0.539	37.9	1.25	98.0	19.9
		0.776	54.6	1.80	91.6	18.6
		1.057	74.3	2.45	85.0	17.2
		1.38	97.0	3.19	78.5	15.9
		2.16	152	4.99	67.6	13.7
		3.11	218	7.19	57.3	11.6
		4.23	297	9.78	49.3	10.0
		5.52	388	12.8	43.8	8.9
		6.99	491	16.2	40.9	8.3
		8.63	607	20.0	38.9	7.9
		19.41	1365	44.9	34.0	6.9

Table B-2
Capillary Pressure Data
Mission Valley Terminal, San Diego, CA
LFR 002-10180-13

SAMPLE ID	DEPTH INTERVAL	Capillary Pressure		Height Above Water Table, ft	Saturation, % Pore Volume	Moisture, % dry weight
		psi	cm water			
K32 @ 12'	VZ SM	0.000	0.00	0.000	100.0	22.3
		0.086	6.07	0.200	100.0	22.3
		0.194	13.6	0.449	100.0	22.3
		0.345	24.3	0.799	100.0	22.3
		0.539	37.9	1.25	97.8	21.8
		0.776	54.6	1.80	90.0	20.1
		1.057	74.3	2.45	84.2	18.8
		1.38	97.0	3.19	65.0	14.5
		2.16	152	4.99	40.5	9.0
		3.11	218	7.19	33.7	7.5
		4.23	297	9.78	30.2	6.7
		5.52	388	12.8	28.4	6.3
		6.99	491	16.2	26.9	6.0
		8.63	607	20.0	25.4	5.7
		19.41	1365	44.9	22.2	5.0
TA7 @ 12'	NU	0.000	0.00	0.000	100.0	25.3
		0.086	6.07	0.200	100.0	25.3
		0.194	13.6	0.449	100.0	25.3
		0.345	24.3	0.799	95.5	24.2
		0.539	37.9	1.25	78.3	19.8
		0.776	54.6	1.80	58.0	14.7
		1.057	74.3	2.45	45.3	11.5
		1.38	97.0	3.19	39.1	9.9
		2.16	152	4.99	32.7	8.3
		3.11	218	7.19	28.1	7.1
		4.23	297	9.78	22.0	5.6
		5.52	388	12.8	20.5	5.2
		6.99	491	16.2	19.5	5.0
		8.63	607	20.0	17.5	4.5
		19.41	1365	44.9	16.9	4.3
K21 @ 12'	NU	0.000	0.00	0.000	100.0	22.0
		0.086	6.07	0.200	100.0	22.0
		0.194	13.6	0.449	100.0	22.0
		0.345	24.3	0.799	100.0	22.0
		0.539	37.9	1.25	100.0	22.0
		0.776	54.6	1.80	98.5	21.6
		1.057	74.3	2.45	96.7	21.2
		1.38	97.0	3.19	95.2	20.9
		2.16	152	4.99	93.3	20.5
		3.11	218	7.19	91.7	20.1
		4.23	297	9.78	87.0	19.1
		5.52	388	12.8	85.2	18.7
		6.99	491	16.2	83.4	18.3
		8.63	607	20.0	81.5	17.9
		19.41	1365	44.9	76.9	16.9

Table B-2
Capillary Pressure Data
Mission Valley Terminal, San Diego, CA
LFR 002-10180-13

SAMPLE ID	DEPTH INTERVAL	Capillary Pressure		Height Above Water Table, ft	Saturation, % Pore Volume	Moisture, % dry weight
		psi	cm water			
ASM-02-23.5	SZ SW	0.000	0.00	0.000	100.0	24.0
		0.086	6.02	0.198	100.0	24.0
		0.192	13.5	0.445	99.9	24.0
		0.342	24.1	0.792	97.3	23.3
		0.535	37.6	1.24	92.5	22.2
		1.369	96.2	3.17	88.0	21.1
		1.73	121.8	4.01	83.5	20.0
		2.14	150	4.95	80.5	19.3
		3.08	217	7.13	65.5	15.7
		4.19	295	9.70	57.9	13.9
		6.93	487	16.04	53.5	12.9
		8.56	602	19.8	52.0	12.5
		19.25	1353	44.5	50.5	12.1
		0.000	0.00	0.000	100.0	27.4
ASM-02-25.5	SZ SW	0.086	6.02	0.198	100.0	27.4
		0.192	13.5	0.445	98.6	27.1
		0.342	24.1	0.792	93.2	25.6
		0.535	37.6	1.24	77.8	21.4
		1.369	96.2	3.17	57.0	15.7
		1.73	121.8	4.01	45.3	12.4
		2.14	150	4.95	39.3	10.8
		3.08	217	7.13	32.1	8.8
		4.19	295	9.70	26.8	7.4
		6.93	487	16.04	20.0	5.5
		8.56	602	19.8	19.3	5.3
		19.25	1353	44.5	19.0	5.2
		0.000	0.00	0.000	100.0	28.0
AS-07-25	SZ SW	0.092	6.44	0.212	100.0	28.0
		0.206	14.5	0.477	100.0	28.0
		0.367	25.8	0.848	100.0	28.0
		0.573	40.3	1.33	97.3	27.2
		0.825	58.0	1.91	92.1	25.8
		1.12	78.9	2.60	73.2	20.5
		1.47	103	3.39	61.1	17.1
		2.29	161	5.30	44.4	12.5
		3.30	232	7.63	39.7	11.1
		4.49	316	10.39	29.5	8.3
		5.86	412	13.6	24.4	6.9
		7.42	522	17.2	21.7	6.1
		9.16	644	21.2	20.1	5.6
		20.6	1450	47.7	16.3	4.6

Table B-2
Capillary Pressure Data
Mission Valley Terminal, San Diego, CA
LFR 002-10180-13

SAMPLE ID	DEPTH INTERVAL	Capillary Pressure		Height Above Water Table, ft	Saturation, % Pore Volume	Moisture, % dry weight
		psi	cm water			
AS-07-28.5	SZ SW	0.000	0.00	0.000	100.0	31.0
		0.092	6.44	0.212	100.0	31.0
		0.206	14.5	0.477	100.0	31.0
		0.367	25.8	0.848	99.4	30.8
		0.573	40.3	1.33	95.3	29.6
		0.825	58.0	1.91	92.1	28.5
		1.12	78.9	2.60	72.1	22.3
		1.47	103	3.39	58.3	18.1
		2.29	161	5.30	45.5	14.1
		3.30	232	7.63	41.8	13.0
		4.49	316	10.39	32.5	10.1
		5.86	412	13.6	27.2	8.5
		7.42	522	17.2	26.1	8.1
		9.16	644	21.2	24.3	7.6
		20.6	1450	47.7	23.9	7.4
R-49-14.5	VZ SM	0.000	0.00	0.000	100.0	15.1
		0.103	7.22	0.238	99.1	14.9
		0.231	16.3	0.535	98.3	14.8
		0.411	28.9	0.951	96.9	14.6
		0.642	45.1	1.49	96.2	14.5
		0.925	65.0	2.14	95.0	14.3
		1.26	88.5	2.91	91.4	13.7
		1.64	116	3.80	78.7	11.6
		2.57	181	5.94	62.3	9.0
		3.70	260	8.56	52.0	7.3
		5.03	354	11.65	47.5	6.6
		6.57	462	15.2	44.8	6.1
		8.32	585	19.3	41.7	5.6
		10.27	722	23.8	40.0	5.4
		23.1	1625	53.5	35.7	4.7
		64.2	4514	149	33.4	4.3
R-50-14.5	CF MH	0.000	0.00	0.000	100.0	19.5
		0.103	7.22	0.238	100.0	19.5
		0.231	16.3	0.535	100.0	19.5
		0.411	28.9	0.951	100.0	19.5
		0.642	45.1	1.49	100.0	19.5
		0.925	65.0	2.14	100.0	19.5
		1.26	88.5	2.91	98.6	19.2
		1.64	116	3.80	95.3	18.5
		2.57	181	5.94	79.0	15.1
		3.70	260	8.56	70.1	13.2
		5.03	354	11.65	64.3	12.0
		6.57	462	15.2	60.5	11.2
		8.32	585	19.3	56.5	10.4
		10.27	722	23.8	53.1	9.7
		23.1	1625	53.5	48.7	8.8
		64.2	4514	149	45.8	8.1

Table B-2
Capillary Pressure Data
Mission Valley Terminal, San Diego, CA
LFR 002-10180-13

SAMPLE ID	DEPTH INTERVAL	Capillary Pressure		Height Above Water Table, ft	Saturation, % Pore Volume	Moisture, % dry weight
		psi	cm water			
R-51-11.0	CF MH	0.000	0.00	0.000	100.0	20.4
		0.103	7.22	0.238	100.0	20.4
		0.231	16.3	0.535	100.0	20.4
		0.411	28.9	0.951	100.0	20.4
		0.642	45.1	1.49	100.0	20.4
		0.925	65.0	2.14	98.0	19.9
		1.26	88.5	2.91	96.2	19.5
		1.64	116	3.80	93.9	19.0
		2.57	181	5.94	88.0	17.7
		3.70	260	8.56	83.6	16.8
		5.03	354	11.65	78.5	15.7
		6.57	462	15.2	73.9	14.6
		8.32	585	19.3	68.8	13.5
		10.27	722	23.8	65.7	12.9
		23.1	1625	53.5	58.5	11.3
		64.2	4514	149	56.5	10.9
R-52-12.0	CF MH	0.000	0.00	0.000	100.0	17.3
		0.103	7.22	0.238	100.0	17.3
		0.231	16.3	0.535	100.0	17.3
		0.411	28.9	0.951	100.0	17.3
		0.642	45.1	1.49	100.0	17.3
		0.925	65.0	2.14	98.9	17.1
		1.26	88.5	2.91	97.2	16.8
		1.64	116	3.80	96.4	16.6
		2.57	181	5.94	93.4	16.1
		3.70	260	8.56	91.8	15.8
		5.03	354	11.65	90.1	15.5
		6.57	462	15.2	88.5	15.2
		8.32	585	19.3	86.5	14.8
		10.27	722	23.8	84.4	14.4
		23.1	1625	53.5	79.0	13.4
		64.2	4514	149	77.3	13.1
R-53-13.5	CF MH	0.000	0.00	0.000	100.0	17.9
		0.103	7.22	0.238	100.0	17.9
		0.231	16.3	0.535	100.0	17.9
		0.411	28.9	0.951	100.0	17.9
		0.642	45.1	1.49	100.0	17.9
		0.925	65.0	2.14	100.0	17.9
		1.26	88.5	2.91	100.0	17.9
		1.64	116	3.80	98.9	17.7
		2.57	181	5.94	98.0	17.5
		3.70	260	8.56	96.7	17.2
		5.03	354	11.65	95.6	17.0
		6.57	462	15.2	94.5	16.8
		8.32	585	19.3	92.3	16.4
		10.27	722	23.8	90.9	16.1
		23.1	1625	53.5	83.5	14.7
		64.2	4514	149	82.7	14.6

Table B-2
Capillary Pressure Data
Mission Valley Terminal, San Diego, CA
LFR 002-10180-13

SAMPLE ID	DEPTH INTERVAL	Capillary Pressure		Height Above Water Table, ft	Saturation, % Pore Volume	Moisture, % dry weight
		psi	cm water			
R-54-12.5	CF MH	0.000	0.00	0.000	100.0	20.8
		0.103	7.22	0.238	100.0	20.8
		0.231	16.3	0.535	100.0	20.8
		0.411	28.9	0.951	100.0	20.8
		0.642	45.1	1.49	100.0	20.8
		0.925	65.0	2.14	100.0	20.8
		1.26	88.5	2.91	98.7	20.5
		1.64	116	3.80	97.5	20.3
		2.57	181	5.94	95.9	19.9
		3.70	260	8.56	93.6	19.4
		5.03	354	11.65	91.8	19.0
		6.57	462	15.2	90.2	18.6
		8.32	585	19.3	88.3	18.2
		10.27	722	23.8	86.8	17.9
		23.1	1625	53.5	82.2	16.8
		64.2	4514	149	81.1	16.6

Note:

Laboratory Analysis performed by: PTS Laboratories, Inc.

Analytical method = ASTM D425M, Centrifugal Method: air displacing water

NU = Sample collected from onsite area and is not used in analysis

VZ SM - Vadose Zone Silty Sand

CF MH - Capillary Fringe Clayey Silt

SZ SW - Saturated Zone Well Graded Sand

Table B-3
Soil Properties Data Statistics
Mission Valley Terminal, San Diego, CA
LFR 002-10180-13

Soil Type ⁽¹⁾	Soil Density (g/cc)						Porosity (% Vb)						Water Saturation (% Pv)			Permeability (millidarcy)			van Genuchten Capillary Pressure Parameters						
	Bulk			Grain			Total			Native State Air Filled															
	Arithmetic Mean	σ	n	Arithmetic Mean	σ	n	Arithmetic Mean	σ	n	Arithmetic Mean	σ	n	Geometric Mean	$\sigma_{\log(k)}$	n	Fitted	$se_{\log(a)}$	Fitted	se	Fitted	se	n			
VZ SM	1.58	0.13	17	2.65	0.03	16	39.9	5.0	16	17.0	9.6	16	58.7	21.1	16	1.5E+03	0.87	4	1.02	0.08	2.264	0.530	0.39	0.07	4
CF MH	1.60	0.10	9	2.64	0.00	8	40.1	3.5	8	9.0	4.1	8	77.2	9.0	8	6.2E+00	0.79	5	0.47	0.11	2.010	0.523	0.67	0.05	5
SZ SW	1.54	0.10	8	2.64	0.14	8	39.6	4.8	8	13.2	10.3	4	65.7	23.6	4	3.5E+04	NA	1	1.25	0.05	2.279	0.324	0.25	0.05	5

Notes:

VZ SM - Vadose Zone Silty Sand

CF MH - Capillary Fringe Clayey Silt

SZ SW - Saturated Zone Well Graded Sand

Figure B-1
Silty Sand Depth Interval Water Retention
 Mission Valley Terminal, San Diego, California

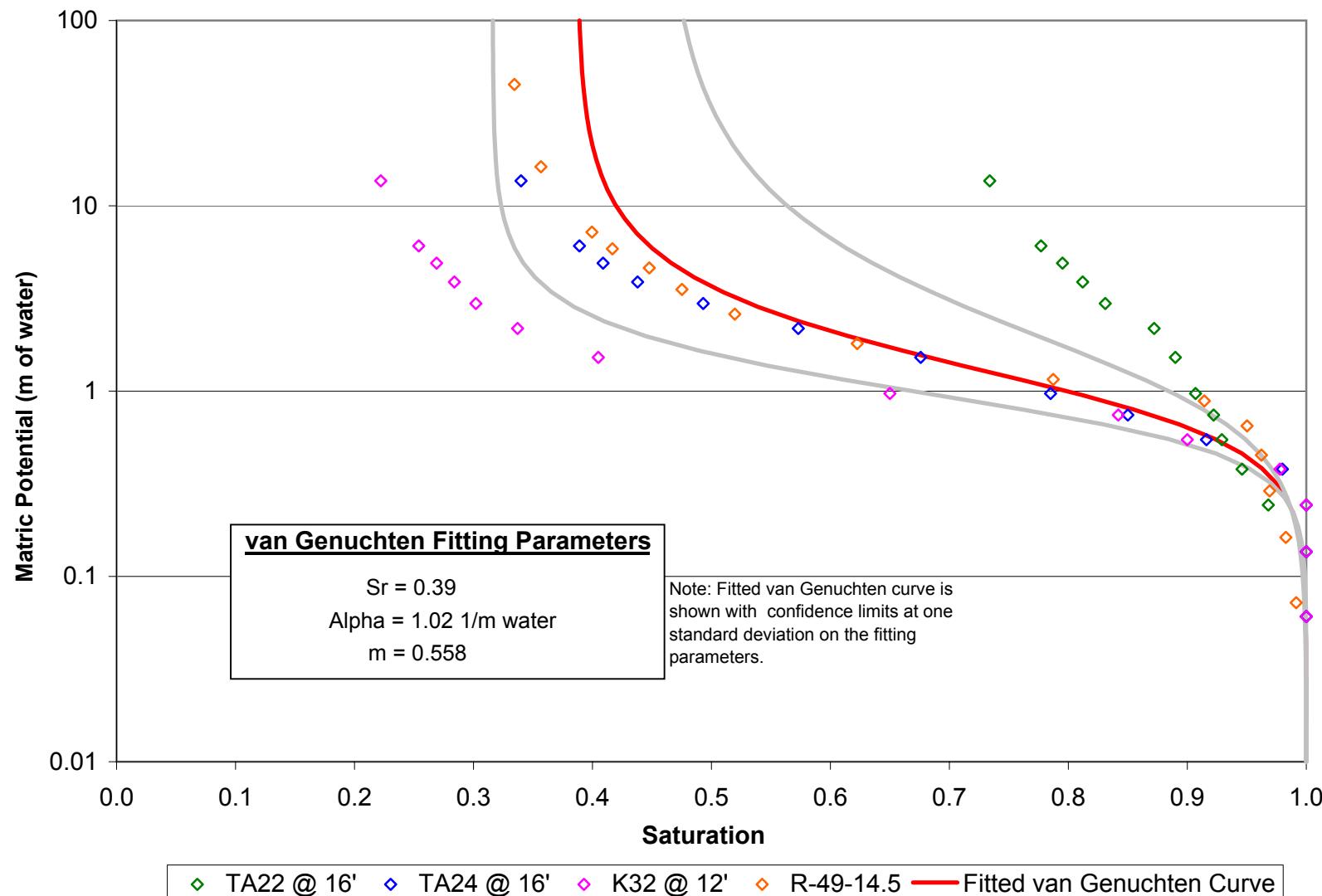


Figure B-2
Clayey Silt Depth Interval Water Retention
 Mission Valley Terminal, San Diego, California

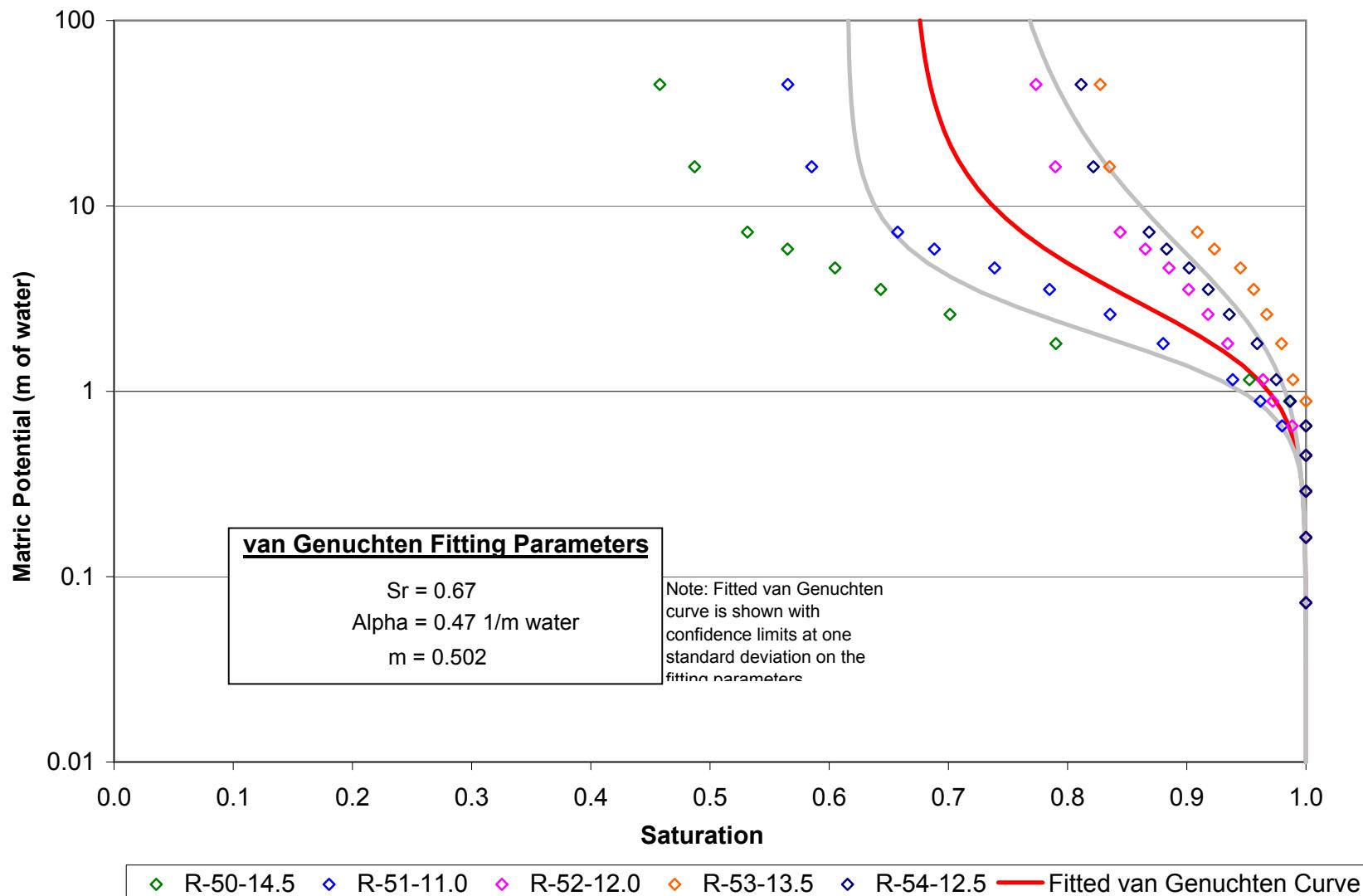
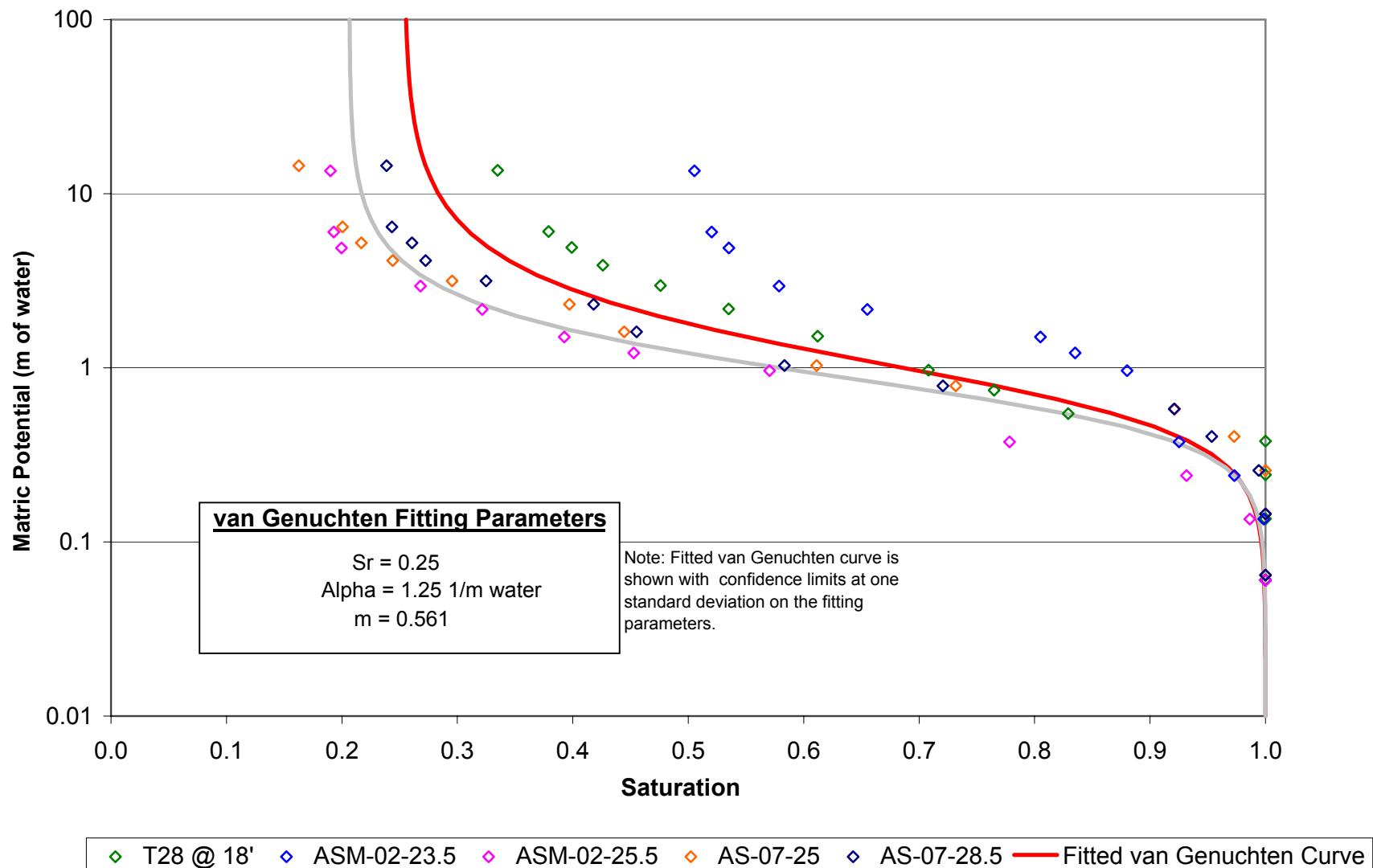


Figure B-3
Well-Graded Sand Depth Interval Water Retention
 Mission Valley Terminal, San Diego, California



ATTACHMENT B-1

Analytical Laboratory Reports

PHYSICAL PROPERTIES DATA

DRY BULK DENSITY OF IN-PLACE SOIL - ASTM D 2937

PROJECT NAME MVT

PROJECT NO: 002-10180-10-004

SAMPLE ID.	DEPTH, ft.	METHODS: MEASURED		ASTM D 2216/ASTM D 2937	
		TOTAL SAMPLE VOLUME cc	MOISTURE CONTENT (% wt)	VOLUMETRIC MOISTURE CONTENT AS FRACTION OF Vb (cm ³ /cm ³)	DRY BULK DENSITY, g/cc
SV-16-8.5	n/a	172.52	12.8	0.19	1.46
SV-16-17.5	n/a	155.68	13.1	0.23	1.74
SV-17-6.9	n/a	142.34	22.0	0.34	1.57
SV-17-9.5	n/a	137.83	20.8	0.37	1.77

PHYSICAL PROPERTIES DATA

SPECIFIC GRAVITY OF SOILS BY PYCNOMETER - ASTM D 854

PROJECT NAME: MVT

PROJECT NO: 002-10180-10-004

SAMPLE ID.	DEPTH, ft.	TEMP. °C	TEMPERATURE CORRECTION FACTOR	MASS OF PYCNOMETER AND WATER, g	MASS OF OVEN DRY SOIL, g	MASS OF PYCNOMETER, OVEN DRY SOIL AND WATER, g	SPECIFIC GRAVITY AT TEMPERATURE	SPECIFIC GRAVITY AT 20°C
SV-16-8.5	n/a	22.5	0.9995	73.3737	32.4991	93.6133	2.65	2.65
SV-16-17.5	n/a	22.5	0.9995	71.8660	26.8485	88.4752	2.62	2.62
SV-17-6.9	n/a	22.5	0.9995	75.0599	21.1189	88.0932	2.61	2.61
SV-17-9.5	n/a	22.5	0.9995	72.7599	21.4176	86.0768	2.64	2.64

MOISTURE, ASH, AND ORGANIC MATTER

(Method: ASTM D 2974)

PROJECT NAME: MVT
PROJECT NO: 002-10180-10-004

SAMPLE ID.	DEPTH, ft.	SAMPLE ORIENTATION (1)	MOISTURE CONTENT (% dry wt)	ASH CONTENT (% dry wt)	ORGANIC CONTENT (% dry wt)
SV-16-8.5	n/a	bulk	11.4	99.8	0.22
SV-16-17.5	n/a	bulk	12.6	99.3	0.66
SV-17-6.9	n/a	bulk	21.8	98.4	1.58
SV-17-9.5	n/a	bulk	21.9	98.7	1.32

(1) Sample Orientation: H = horizontal; V = vertical

PARTICLE SIZE SUMMARY
 (METHODOLOGY: ASTM D422/D4464M)

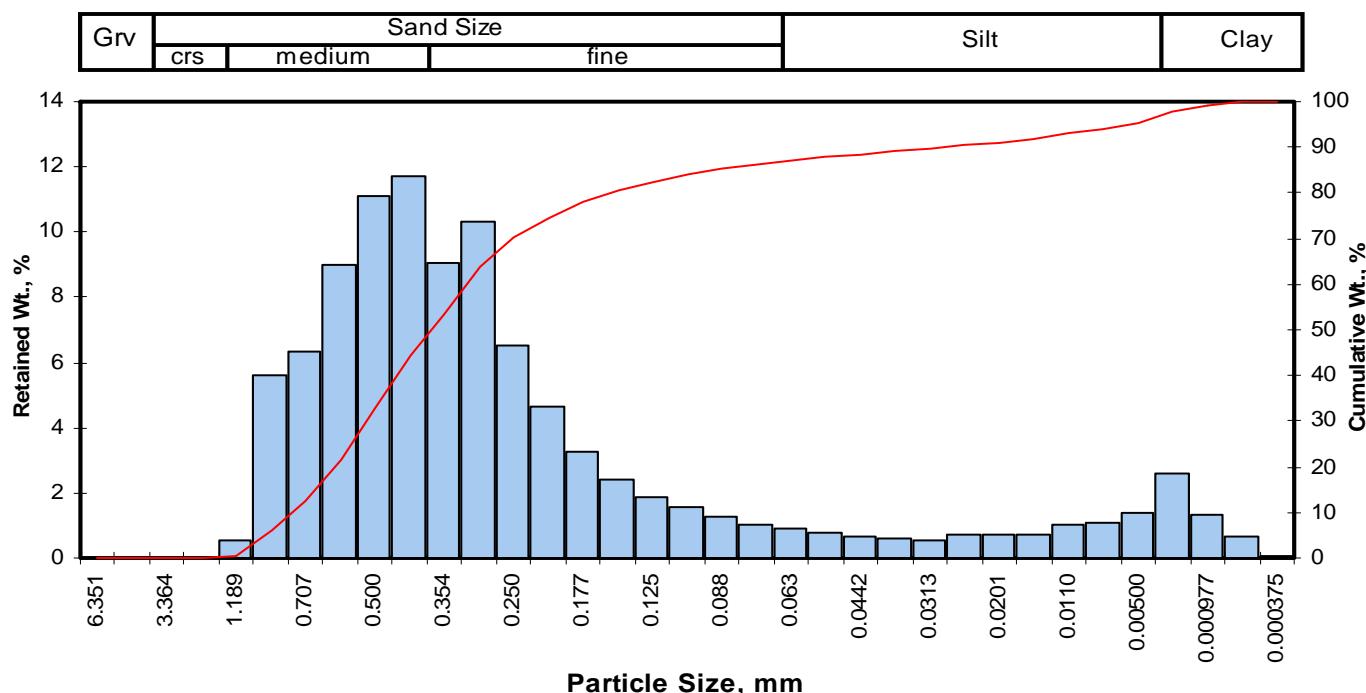
PROJECT NAME: MVT
 PROJECT NO: 002-10180-10-004

Sample ID	Depth, ft.	Mean Grain Size Description (1)	Median Grain Size mm	Particle Size Distribution, wt. percent							Silt & Clay	
				Gravel	Sand Size			Silt	Clay			
					Coarse	Medium	Fine					
SV-16-8.5	8.50	Fine sand	0.377	0.00	0.00	44.26	41.95	9.17	4.61	13.78		
SV-16-17.5	17.50	Fine sand	0.209	0.00	0.00	21.94	44.08	20.32	13.65	33.98		
SV-17-6.9	6.90	Fine sand	0.043	0.00	0.00	8.58	32.47	38.94	20.01	58.95		
SV-17-9.5	9.50	Fine sand	0.065	0.00	0.00	6.07	41.22	35.63	17.09	52.71		

(1) Based on Mean from Trask

Client: LFR
Project: MVT
Project No: 002-10180-10-004

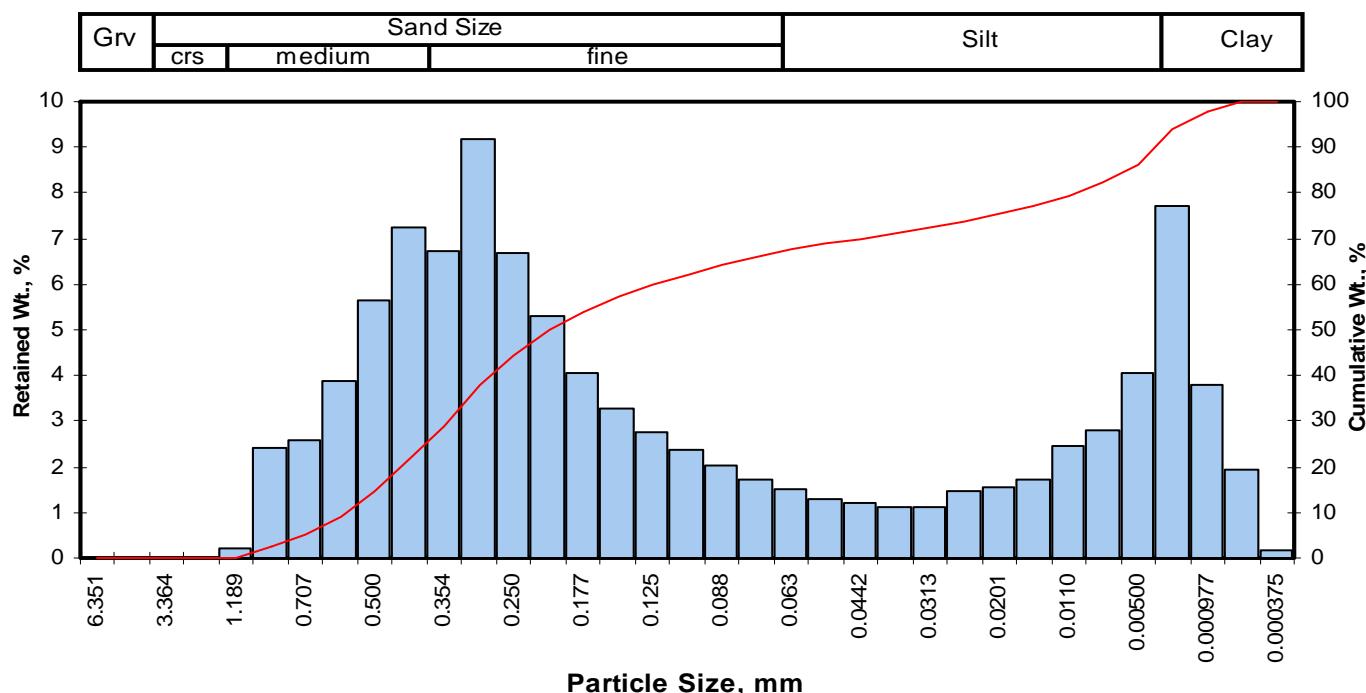
PTS File No: 33707
Sample ID: SV-16-8.5
Depth, ft: 8.50



Opening		Phi of Screen	U.S. No.	Sample Weight, grams	Increment Weight, percent	Cumulative Weight, percent	Cumulative Weight Percent greater than			
Inches	Millimeters						Weight percent	Phi Value	Particle Size	
							Inches	Millimeters		
0.2500	6.351	-2.67	1/4	0.00	0.00	0.00	5	0.15	0.0356	0.903
0.1873	4.757	-2.25	4	0.00	0.00	0.00	10	0.40	0.0298	0.757
0.1324	3.364	-1.75	6	0.00	0.00	0.00	16	0.60	0.0260	0.661
0.0787	2.000	-1.00	10	0.00	0.00	0.00	25	0.83	0.0222	0.563
0.0468	1.189	-0.25	16	0.53	0.53	0.53	40	1.16	0.0176	0.448
0.0331	0.841	0.25	20	5.63	5.63	6.16	50	1.41	0.0148	0.377
0.0278	0.707	0.50	25	6.31	6.31	12.47	60	1.66	0.0124	0.316
0.0234	0.595	0.75	30	8.98	8.98	21.46	75	2.27	0.0082	0.208
0.0197	0.500	1.00	35	11.10	11.10	32.56	84	3.27	0.0041	0.104
0.0166	0.420	1.25	40	11.70	11.70	44.26	90	5.14	0.0011	0.028
0.0139	0.354	1.50	45	9.03	9.03	53.30	95	7.47	0.0002	0.006
0.0117	0.297	1.75	50	10.30	10.30	63.60				
0.0098	0.250	2.00	60	6.51	6.51	70.11				
0.0083	0.210	2.25	70	4.65	4.65	74.76				
0.0070	0.177	2.50	80	3.27	3.27	78.03				
0.0059	0.149	2.75	100	2.43	2.43	80.46				
0.0049	0.125	3.00	120	1.90	1.90	82.36				
0.0041	0.105	3.25	140	1.54	1.54	83.90				
0.0035	0.088	3.50	170	1.26	1.26	85.16				
0.0029	0.074	3.75	200	1.05	1.05	86.22				
0.0025	0.063	4.00	230	0.89	0.89	87.11				
0.0021	0.053	4.25	270	0.76	0.76	87.87				
0.00174	0.0442	4.50	325	0.66	0.66	88.53				
0.00146	0.0372	4.75	400	0.60	0.60	89.13				
0.00123	0.0313	5.00	450	0.57	0.57	89.70				
0.000986	0.0250	5.32	500	0.71	0.71	90.41				
0.000790	0.0201	5.64	635	0.70	0.70	91.11				
0.000615	0.0156	6.00		0.75	0.75	91.86				
0.000435	0.0110	6.50		1.05	1.05	92.91				
0.000308	0.00781	7.00		1.08	1.08	93.99				
0.000197	0.00500	7.65		1.40	1.40	95.39				
0.000077	0.00195	9.00		2.60	2.60	97.99				
0.000038	0.000977	10.00		1.31	1.31	99.30				
0.000019	0.000488	11.00		0.64	0.64	99.94				
0.000015	0.000375	11.38		0.06	0.06	100.00				
TOTALS				100.00	100.00	100.00				

Client: LFR
Project: MVT
Project No: 002-10180-10-004

PTS File No: 33707
Sample ID: SV-16-17.5
Depth, ft: 17.50



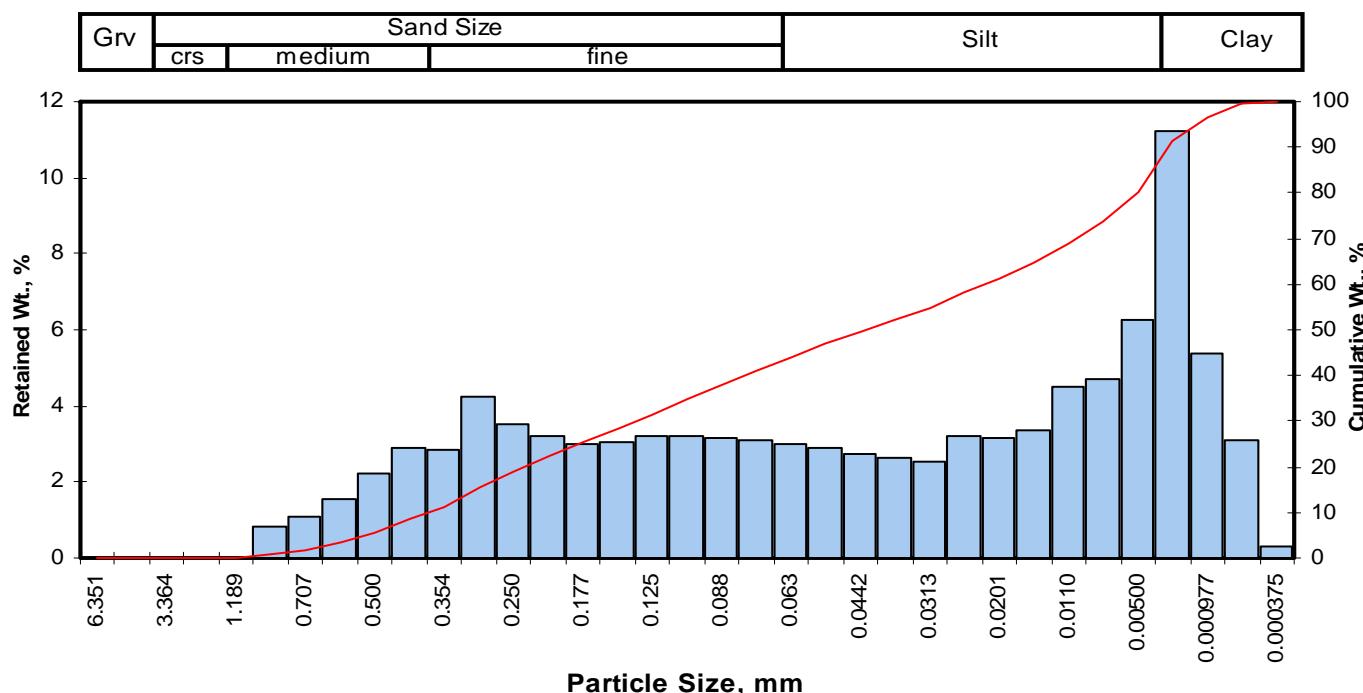
Opening		Phi of Screen	U.S. No.	Sample Weight, grams	Increment Weight, percent	Cumulative Weight, percent	Cumulative Weight Percent greater than			
Inches	Millimeters						Weight percent	Phi Value	Particle Size	
							Inches	Millimeters		
0.2500	6.351	-2.67	1/4	0.00	0.00	0.00	5	0.48	0.0282	0.716
0.1873	4.757	-2.25	4	0.00	0.00	0.00	10	0.79	0.0227	0.578
0.1324	3.364	-1.75	6	0.00	0.00	0.00	16	1.04	0.0191	0.485
0.0787	2.000	-1.00	10	0.00	0.00	0.00	25	1.36	0.0153	0.389
0.0468	1.189	-0.25	16	0.21	0.21	0.21	40	1.83	0.0111	0.281
0.0331	0.841	0.25	20	2.41	2.41	2.62	50	2.26	0.0082	0.209
0.0278	0.707	0.50	25	2.57	2.57	5.19	60	3.01	0.0049	0.124
0.0234	0.595	0.75	30	3.87	3.87	9.06	75	5.58	0.0008	0.021
0.0197	0.500	1.00	35	5.64	5.64	14.70	84	7.27	0.0003	0.006
0.0166	0.420	1.25	40	7.24	7.24	21.94	90	8.29	0.0001	0.003
0.0139	0.354	1.50	45	6.72	6.72	28.67	95	9.25	0.0001	0.002
0.0117	0.297	1.75	50	9.16	9.16	37.83				
0.0098	0.250	2.00	60	6.70	6.70	44.53				
0.0083	0.210	2.25	70	5.29	5.29	49.82				
0.0070	0.177	2.50	80	4.05	4.05	53.87				
0.0059	0.149	2.75	100	3.27	3.27	57.14				
0.0049	0.125	3.00	120	2.76	2.76	59.90				
0.0041	0.105	3.25	140	2.37	2.37	62.27				
0.0035	0.088	3.50	170	2.02	2.02	64.29				
0.0029	0.074	3.75	200	1.73	1.73	66.02				
0.0025	0.063	4.00	230	1.49	1.49	67.51				
0.0021	0.053	4.25	270	1.31	1.31	68.82				
0.00174	0.0442	4.50	325	1.20	1.20	70.02				
0.00146	0.0372	4.75	400	1.14	1.14	71.16				
0.00123	0.0313	5.00	450	1.12	1.12	72.28				
0.000986	0.0250	5.32	500	1.47	1.47	73.75				
0.000790	0.0201	5.64	635	1.55	1.55	75.31				
0.000615	0.0156	6.00		1.72	1.72	77.03				
0.000435	0.0110	6.50		2.46	2.46	79.49				
0.000308	0.00781	7.00		2.82	2.82	82.31				
0.000197	0.00500	7.65		4.04	4.04	86.35				
0.000077	0.00195	9.00		7.71	7.71	94.06				
0.000038	0.000977	10.00		3.81	3.81	97.87				
0.000019	0.000488	11.00		1.94	1.94	99.81				
0.000015	0.000375	11.38		0.19	0.19	100.00				
TOTALS				100.00	100.00	100.00				

PTS Laboratories, Inc.

Particle Size Analysis - ASTM D4464M

Client: LFR
Project: MVT
Project No: 002-10180-10-004

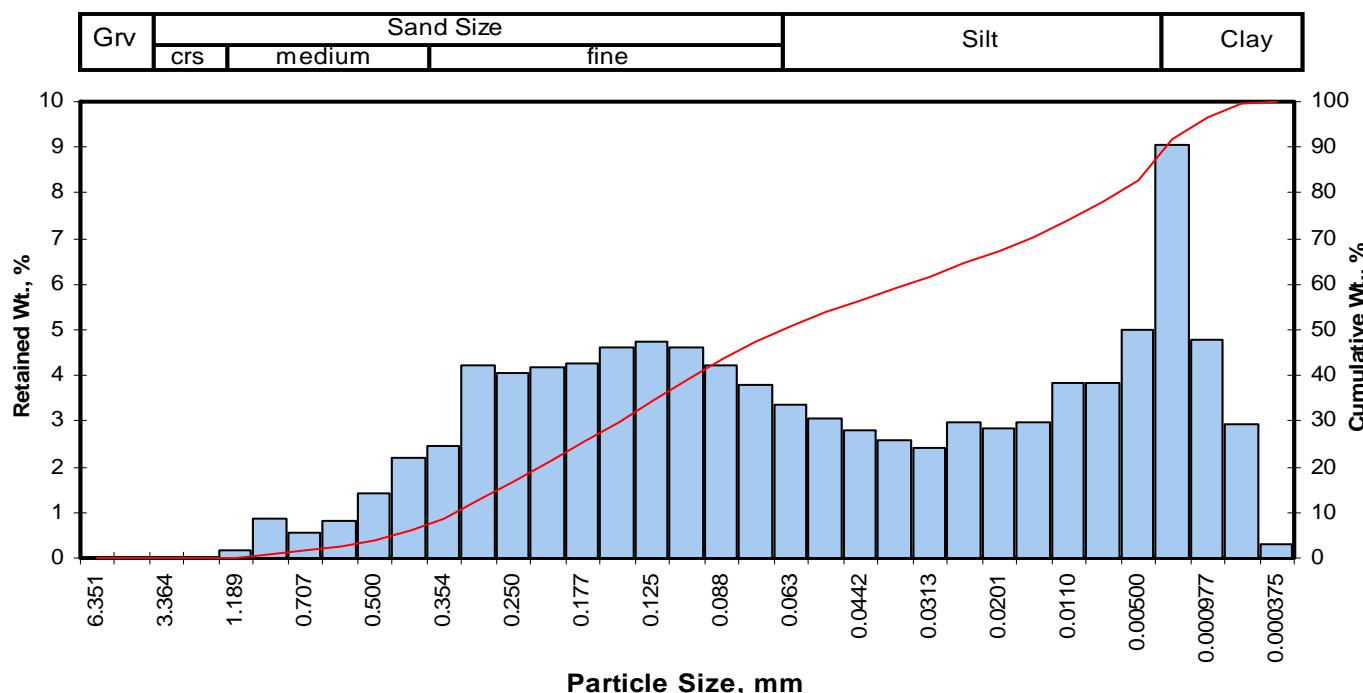
PTS File No: 33707
Sample ID: SV-17-6.9
Depth, ft: 6.90



Opening		Phi of Screen	U.S. No.	Sample Weight, grams	Increment Weight, percent	Cumulative Weight, percent	Cumulative Weight Percent greater than			
Inches	Millimeters						Weight percent	Phi Value	Particle Size	
							5	0.92	0.0208	0.528
0.2500	6.351	-2.67	1/4	0.00	0.00	0.00	10	1.38	0.0152	0.385
0.1873	4.757	-2.25	4	0.00	0.00	0.00	16	1.78	0.0115	0.292
0.1324	3.364	-1.75	6	0.00	0.00	0.00	25	2.47	0.0071	0.180
0.0787	2.000	-1.00	10	0.00	0.00	0.00	40	3.67	0.0031	0.079
0.0468	1.189	-0.25	16	0.02	0.02	0.02	50	4.53	0.0017	0.043
0.0331	0.841	0.25	20	0.83	0.83	0.85	60	5.52	0.0009	0.022
0.0278	0.707	0.50	25	1.06	1.06	1.92	75	7.13	0.0003	0.007
0.0234	0.595	0.75	30	1.57	1.57	3.49	84	8.13	0.0001	0.004
0.0197	0.500	1.00	35	2.21	2.21	5.70	90	8.86	0.0001	0.002
0.0166	0.420	1.25	40	2.88	2.88	8.58	95	9.71	0.0000	0.001
0.0139	0.354	1.50	45	2.83	2.83	11.41				
0.0117	0.297	1.75	50	4.23	4.23	15.64				
0.0098	0.250	2.00	60	3.49	3.49	19.13				
0.0083	0.210	2.25	70	3.20	3.20	22.34				
0.0070	0.177	2.50	80	2.98	2.98	25.32				
0.0059	0.149	2.75	100	3.07	3.07	28.39				
0.0049	0.125	3.00	120	3.18	3.18	31.57				
0.0041	0.105	3.25	140	3.22	3.22	34.79				
0.0035	0.088	3.50	170	3.16	3.16	37.96				
0.0029	0.074	3.75	200	3.09	3.09	41.05				
0.0025	0.063	4.00	230	3.00	3.00	44.05				
0.0021	0.053	4.25	270	2.87	2.87	46.92				
0.00174	0.0442	4.50	325	2.74	2.74	49.66				
0.00146	0.0372	4.75	400	2.63	2.63	52.29				
0.00123	0.0313	5.00	450	2.54	2.54	54.83				
0.000986	0.0250	5.32	500	3.19	3.19	58.03				
0.000790	0.0201	5.64	635	3.14	3.14	61.17				
0.000615	0.0156	6.00		3.34	3.34	64.51				
0.000435	0.0110	6.50		4.49	4.49	69.00				
0.000308	0.00781	7.00		4.70	4.70	73.71				
0.000197	0.00500	7.65		6.28	6.28	79.99				
0.000077	0.00195	9.00		11.20	11.21	91.20				
0.000038	0.000977	10.00		5.39	5.39	96.59				
0.000019	0.000488	11.00		3.08	3.08	99.67				
0.000015	0.000375	11.38		0.33	0.33	100.00				
TOTALS				99.90	100.00	100.00				

Client: LFR
Project: MVT
Project No: 002-10180-10-004

PTS File No: 33707
Sample ID: SV-17-9.5
Depth, ft: 9.50



Opening		Phi of Screen	U.S. No.	Sample Weight, grams	Increment Weight, percent	Cumulative Weight, percent	Cumulative Weight Percent greater than			
Inches	Millimeters						Weight percent	Phi Value	Particle Size	
							Inches	Millimeters		
0.2500	6.351	-2.67	1/4	0.00	0.00	0.00	5	1.13	0.0180	0.458
0.1873	4.757	-2.25	4	0.00	0.00	0.00	10	1.59	0.0131	0.333
0.1324	3.364	-1.75	6	0.00	0.00	0.00	16	1.95	0.0102	0.259
0.0787	2.000	-1.00	10	0.00	0.00	0.00	25	2.48	0.0070	0.179
0.0468	1.189	-0.25	16	0.19	0.19	0.19	40	3.29	0.0040	0.102
0.0331	0.841	0.25	20	0.88	0.88	1.07	50	3.95	0.0025	0.065
0.0278	0.707	0.50	25	0.56	0.56	1.63	60	4.84	0.0014	0.035
0.0234	0.595	0.75	30	0.84	0.84	2.47	75	6.62	0.0004	0.010
0.0197	0.500	1.00	35	1.42	1.42	3.89	84	7.81	0.0002	0.004
0.0166	0.420	1.25	40	2.18	2.18	6.07	90	8.71	0.0001	0.002
0.0139	0.354	1.50	45	2.45	2.45	8.52	95	9.63	0.0000	0.001
0.0117	0.297	1.75	50	4.24	4.24	12.76				
0.0098	0.250	2.00	60	4.07	4.07	16.83				
0.0083	0.210	2.25	70	4.20	4.20	21.03				
0.0070	0.177	2.50	80	4.28	4.28	25.31				
0.0059	0.149	2.75	100	4.60	4.60	29.91				
0.0049	0.125	3.00	120	4.75	4.75	34.66				
0.0041	0.105	3.25	140	4.62	4.62	39.28				
0.0035	0.088	3.50	170	4.22	4.22	43.50				
0.0029	0.074	3.75	200	3.79	3.79	47.29				
0.0025	0.063	4.00	230	3.38	3.38	50.66				
0.0021	0.053	4.25	270	3.05	3.05	53.71				
0.00174	0.0442	4.50	325	2.79	2.79	56.50				
0.00146	0.0372	4.75	400	2.59	2.59	59.09				
0.00123	0.0313	5.00	450	2.43	2.43	61.52				
0.000986	0.0250	5.32	500	2.96	2.96	64.48				
0.000790	0.0201	5.64	635	2.85	2.85	67.33				
0.000615	0.0156	6.00		2.96	2.96	70.29				
0.000435	0.0110	6.50		3.82	3.82	74.11				
0.000308	0.00781	7.00		3.82	3.82	77.93				
0.000197	0.00500	7.65		4.98	4.98	82.91				
0.000077	0.00195	9.00		9.06	9.06	91.97				
0.000038	0.000977	10.00		4.78	4.78	96.75				
0.000019	0.000488	11.00		2.93	2.93	99.68				
0.000015	0.000375	11.38		0.32	0.32	100.00				
TOTALS				100.00	100.00	100.00				

PHYSICAL PROPERTIES DATA

PROJECT NAME: MVT
 PROJECT NO: 002-10180-10-004

SAMPLE ID.	DEPTH, ft.	SAMPLE ORIENT. (1)	MOISTURE CONTENT (% wt)	METHODOLOGY: ASTM D2216		API RP40		API RP40		API RP40	
				BULK (g/cc)	GRAIN (g/cc)	POROSITY, %Vb (2)	TOTAL	AIR FILLED	TOTAL PORE FLUID SATURATIONS, (% Pv (3))	25.0 PSI CONFINING STRESS NATIVE STATE EFFECTIVE PERMEABILITY TO AIR (4) (millidarcy)	
RW-22-21-22.5	21.2	V	16.1	1.55	2.63	41.0	16.0	60.9		1210	
RW-24-17.5	17.2	V	17.1	1.71	2.63	35.1	5.6	84.1		63.0	
RW-26-17.5	17.5	V	10.2	1.53	2.63	41.8	25.9	38.0		2758	
RW-27-17-18	17.5	V	8.5	1.53	2.66	42.6	29.5	30.8		1247	
RW-29-15.5-16.5	16.0	V	19.5	1.59	2.63	39.5	8.1	79.5		18.1	
RW-33-12	12.0	V	7.0	1.35	2.64	48.9	39.4	19.4		6570	
RW-34-11.5-12.5	12.5	V	18.8	1.59	2.63	39.7	9.5	76.1		9.74	

(1) Sample Orientation: H = horizontal; V = vertical (2) Total Porosity = no pore fluids in place; all interconnected pore channels; Air Filled = pore channels not occupied by pore fluids (3)
 Water = 0.9981 g/cc; Hydrocarbon = 0.7500 g/cc (4) Native State = As received with pore fluids in place Vb = Bulk Volume, cc; Pv = Pore Volume, cc; ND = Not Detected